



Inventory and conservation priorities for amphibian species from Cerro Verde (Rocha, Uruguay) and surroundings

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Abstract: Cerro Verde Protected Area, on the coast of Uruguay, serves mainly to protect the marine fauna, which has charismatic species including marine turtles and dolphins. However, the terrestrial portion of this area has the conditions for hosting a great diversity of amphibians. The aims of this study were to build the inventory of amphibians from Cerro Verde, to assess its completeness and to compare it with the inventory constructed from historical records. Acoustic surveys were conducted monthly from 2007 to 2009 at 16 water bodies of the area. Nineteen species were found during this sampling period; the accumulation curve of richness showed an asymptotic pattern, indicating the completeness of the inventory. However, species previously collected in the area were not found during this study, suggesting a loss of diversity in the last decades.

Key words: anurans, conservation, inventory completeness, protected area

INTRODUCTION

The efforts to preserve biodiversity allow the future maintenance of services that benefit the human species (Myers 1996). The creation of protected areas is the cornerstone on which regional strategies for biodiversity conservation are built (Margules and Pressey 2000). However, in absence of local information about some groups, there is a risk that actions aimed at maintaining the biodiversity as a whole were not successful (Sutherland et al. 2004). In Uruguay, the recent implementation of a National System of Protected Areas (SNAP) has improved the possibilities to preserve the local biota (DINAMA 2010). Cerro Verde (Rocha, Uruguay) is a coastal-marine area established in 2011 as a protected area of the SNAP. The purpose of this area was the protection of the marine habitats because of the presence of many charismatic species such as marine turtles (mainly *Chelonia mydas* and *Caretta caretta*) and dolphins

(*Tursiops truncatus*, *Pontoporia blainvillei*) (López et al. 2005). However, the terrestrial portion of this the area has a significant environmental heterogeneity which, added to the presence of several water bodies, favors a high diversity of anurans (López et al. 2005). This high diversity is also expected since the east coast of Uruguay is one of the richest regions of the country concerning amphibian species (Maneyro and Carreira 2006).

To date, extensive studies on amphibian species in Cerro Verde and surroundings have not been carried out; therefore, the information available for this area is composed by sparse records from scientific collections (Núñez et al. 2004) or bibliographic references about particular species (Kolenc et al. 2009; Bardier et al. 2011). Species richness is the basic information that must be taken into account in conservation planning (Scott 2001). The inventories constructed only from scientific collections and/or bibliography, although useful when no other information is available, might lack standardization in data collection and could lead to erroneous conclusions about the presence of species (Moreno 2001). Whenever possible, replicated field surveys allow a better estimation of total species richness and the inventory completeness of an area (Moreno 2001). The knowledge of the identity of the species from the current assemblage allows the comparison with historical records, which helps determining the situation of the local populations. Moreover, the list of species can be used for setting conservation priorities for the area, based on their local situation and conservation status, which can be better supported when consensual lists of priorities at a national or regional level are available. In this sense, Uruguay has defined a list of priority species for conservation in protected areas (Soutullo et al. 2013); the combination of the previous information with this list, is a useful tool to focus the conservation efforts.

The aims of this study are: 1) to obtain the inventory of amphibians of Cerro Verde from field surveys, 2) to evaluate its completeness, 3) to compare this inventory

with the historical records available in scientific collections and 4) to propose a list of species considered as priority for conservation to Cerro Verde.

MATERIALS AND METHODS

Data were collected in Cerro Verde Protected Area ($33^{\circ}56'39.81''$ S, $053^{\circ}31'03.29''$ W; Rocha, Uruguay). This area has marine portion with two islands, and a small terrestrial portion of 14 km² (island surface not included) (Figure 1). It is characterized for having a subtropical humid climate, an average temperature of 16°C and an accumulated annual rainfall of 950 mm. The oceanic coast has elevations (from 20 to 30 m above sea level) and plains with sand dunes (Alonso and Bassagoda 2003).

To determine the list of species recorded in Cerro

Verde, historic records were obtained from the scientific collections of Facultad de Ciencias from Universidad de la República (ZVCB) and Museo Nacional de Historia Natural (MNHN). The MNHN records used were those published by Núñez et al. (2004) and Kolenc et al. (2009) while ZVCB collection was directly reviewed. The animals considered in this list were those collected within the area and a 2 km zone beyond the study area; 2 km is an estimation of the maximum distance a terrestrial amphibian would travel (Wells 2007).

Field surveys were carried out monthly from October 2007 to June 2009, except for January 2009. During each survey, 12 lentic water bodies from the area, and four from the surrounding zone (at a maximum distance of 2 km out of the limits of the area), were sampled (Figure 1). A detailed description of the water bodies is available in

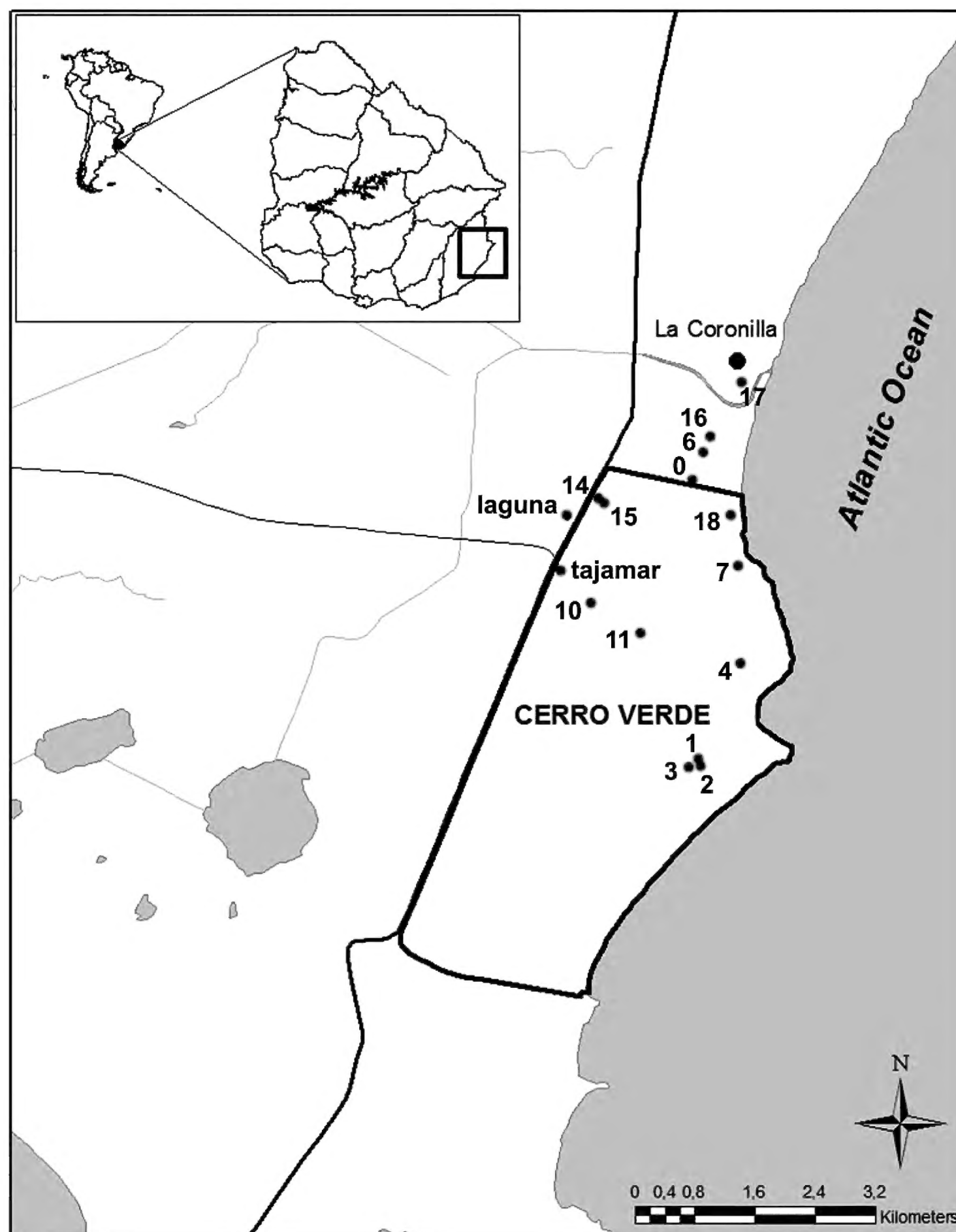


Figure 1. Location of the Cerro Verde Protected Area, Rocha Department, Uruguay. La Coronilla is the nearest populated locality, the points indicate the 16 water bodies surveyed and its denominations.

Table 1. Advertisement calls of adult males were used as an indicator of the presence of the species at each water body (Scott and Woodward 2001). Data were recorded from 19:00 to 00:00 h., during 20 minutes at each pond. In the case of cryptic species, calling males were visually identified, to reduce the chances of erroneous determinations. Whenever it was possible and necessary, one voucher specimen of each species was collected and euthanized in the field using a weak ethanol solution (15%–25%) (Heyer et al. 2001), and stored at Facultad de Ciencias of Universidad de la República (ZVCB).

The accumulation curve of richness, and the number of unique and duplicated species found in each survey *versus* the number of samples were plotted. The point at which the asymptotic behavior of the curve and/or the point at which the “unique” curve meets the “duplicated” curve of species, indicate the completeness of the inventory (Moreno 2001). Also, two non-parametric estimators of richness, ICE and CHAO2 (Moreno 2001), were calculated using the software EstimateS 8.2 (Colwell 2009).

This list was compared with the one obtained from the historic records and both of them were analyzed to look for species considered priorities for conservation in Uruguay (Soutullo et al. 2013).

RESULTS

The list of species from Cerro Verde and surrounding area (represented in field and historic records) has a total of 23 species. This represents 48% of the 48 native species of Uruguay, belonging to six of the seven native anuran families: Bufonidae, Ceratophryidae, Hylidae, Leptodactylidae, Microhylidae and Odontophrynidae (Table 2) (Rosset 2008; Maneyro and Carreira 2012).

Nineteen of these species were identified in the study

area during the nocturnal samplings (Figure 2; Table 2). Among them, *Physalaemus henselii* (Figure 2.14; Table 2) was not previously recorded in the area, and *Scinax berthae* could not be collected, it was only identified by its vocalizations. Vouchers of *S. granulatus*, *S. squalirostris*, *Leptodactylus gracilis*, *L. mystacinus*, *P. riograndensis* and *Elachistocleis bicolor* were collected in the area by the authors in 2004–2005, so it was considered unnecessary to collect them in this opportunity (Table 2).

The asymptotic behavior of the accumulation curve of species presence during acoustic samples, and the intersection of the “unique” and the “duplicated” curves show the completeness of the inventory at the sixth field survey (Figure 3). Both non-parametric estimators, ICE and CHAO2, support the completeness of the inventory

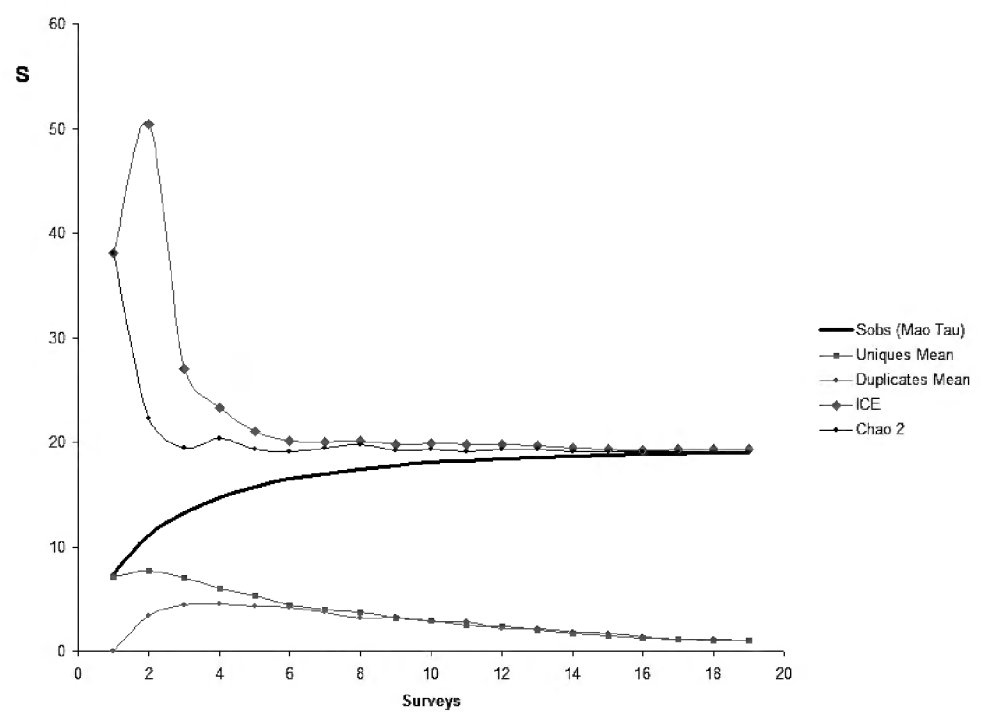


Figure 3. Accumulation curve of richness (S) *versus* number of samples (surveys). Sobs: observed richness, Uniques mean: mean number of species found at only one survey, Duplicates mean: mean number of species found at only two surveys. ICE and CHAO2 are estimators of richness.

Table 1. Main features of the 16 water bodies (WB) surveyed. Margins: environments in the edges of the water bodies, Microhabitats: environments in the inner part of the water body, Landscape Units: environmental matrix. G: grass, M: mud, R: rushes (*Scirpus* sp.), SSH: small-sized herbaceous (i.e.: Cyperaceae, Onagraceae), S: sand, E: *Eryngium* sp., DS: dry soil, SH: shrubs (*Acacia longifolia*), GEV: gramineous and/or other erect vegetation (*Solanum* sp., *Rhynchospora* sp.), WM: water mirror, FEV: floating and/or emergent vegetation (i.e.: *Azolla* sp., *Salvinia* sp., *Nimphoides* sp.), EV: exotic vegetation (*Pinus* sp., *Eucaliptus* sp.), D: dune, U: urbanization. Asterisks indicate those water bodies placed out of the limits of the area.

WB	Geographic Coordinates	Hydroperiod	Water Surface (m²)	Margins	Microhabitats	Landscape Units
0	33°54'40" S, 053°31'08" W	Semipermanent	360	G, M, R, SSH	WM, FEV, R, GEV	G, EV, E
1	33°56'46" S, 053°30'59" W	Temporal	238,42	G, M, SSH, S	WM, SSH	G, EV, D
2	33°56'48" S, 053°30'59" W	Ephemeral	181,76	G, SSH	WM, SSH	G, EV
3	33°56'49" S, 053°31'04" W	Ephemeral	1297,33	G, M, SSH, S	WM, SSH	G, EV, D
4	33°56'05" S, 053°30'41" W	Ephemeral	1506	G, M, SSH, S, E	GEV	G, EV, D
6*	33°54'33" S, 053°30'57" W	Permanent	1457,5	G, M, DS	WM, FEV, R	G, EV
7	33°55'22" S, 053°30'42" W	Permanent	94	G, SSH, S	WM, R	G, EV, D
10	33°55'38" S, 053°31'46" W	Permanent	1972	G, M, E	WM, FEV, E	G, EV, E
11	33°55'51" S, 053°31'25" W	Temporal	607,2	G, SSH, S, SH	WM, SSH	G, EV, D
14	33°54'53" S, 053°31'43" W	Semipermanent	681	G, M, SSH	WM, E	G
15	33°54'54" S, 053°31'41" W	Semipermanent	275	G, S	WM, FEV	G, EV
16*	33°54'26" S, 053°30'54" W	Permanent	884	G, M, SSH, R, GEV	WM, FEV	G, EV, U
17*	33°54'02" S, 053°30'43" W	Permanent	1996,44	G, M, SSH	WM, FEV, SSH	G, U
18	33°55'00" S, 053°30'45" W	Ephemeral	98,49	G, SSH, S	WM, GEV, SSH	G, D
laguna*	33°55'01" S, 053°31'56" W	Permanent	8581	G, M, R, E, DS	WM, FEV	G, U
tajamar	33°55'24" S, 053°32'00" W	Permanent	1347	G, M, E, DS	WM, FEV	G

by predicting a total richness of 19 species (Colwell and Coddington 1994; Moreno 2001).

However, the historic records show the presence of 22 species in Cerro Verde and surrounding area. The species *Argenteohyla siemersi*, *Ceratophrys ornata*, *Odontophrynus americanus* and *Pleurodema bibroni*, were not found during the field surveys (Table 2). We found *P. bibroni* in the area the last day of this study at a pond which was not being surveyed (Bardier et al. 2011), so it was

not used for the accumulation curve, but it was taken account as a species present in the area for the selection of priorities for conservation.

From the total list of 23 species, six of them figure as priorities for conservation in Uruguay: *A. siemersi*, *C. ornata*, *L. latrans*, *M. montevidensis*, *O. maisuma* and *P. bibroni* (Soutullo et al. 2013) (Table 2).

The conservation status of the 23 species is presented in Table 2. At a national level, the threatened

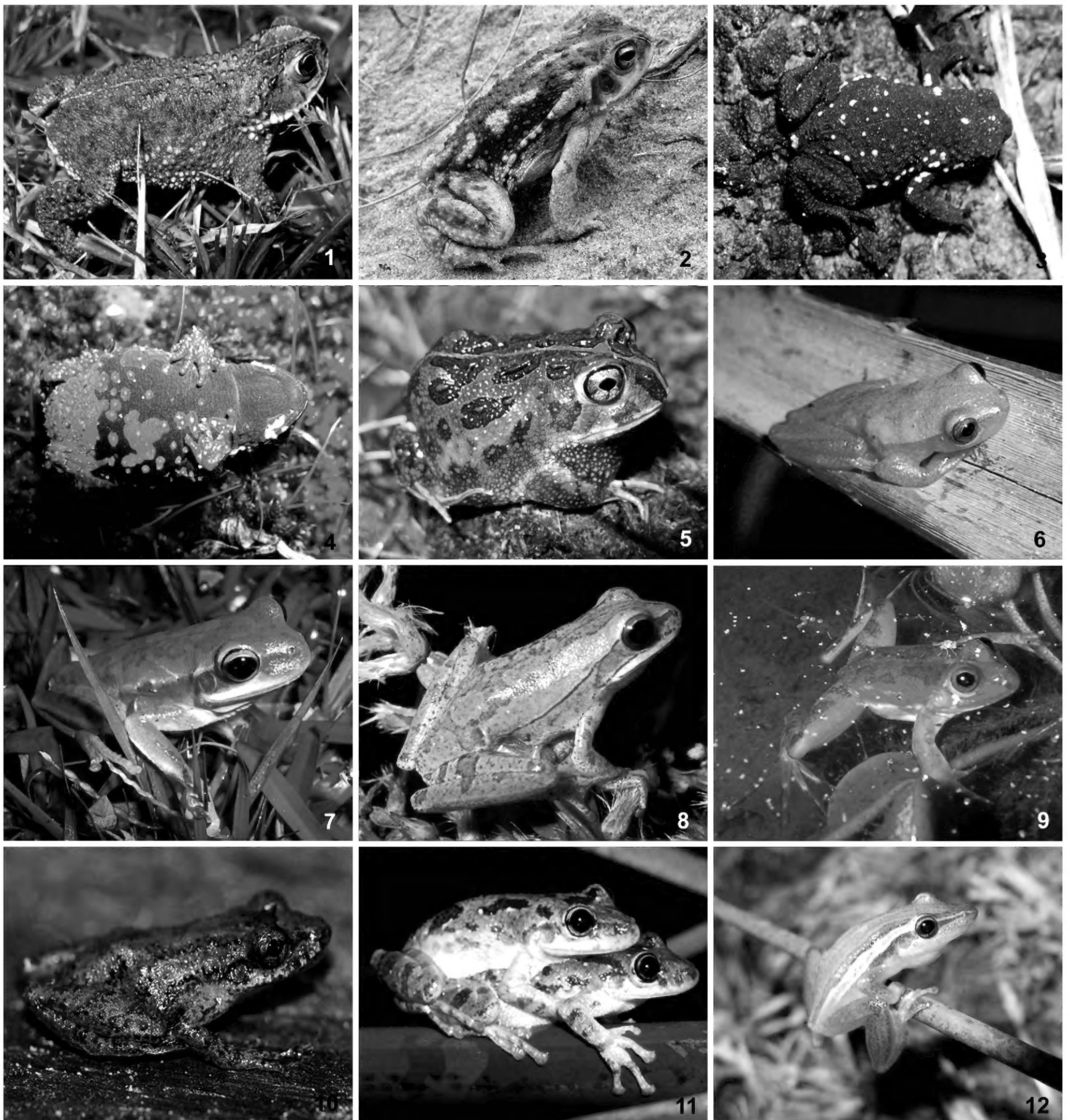


Figure 2. Species found during nocturnal surveys in Cerro Verde. 1) *Rhinella dorbignyi*, 2) *Rhinella arenarum*, 3) and 4) *Melanophryniscus montevidensis* (dorsal and ventral view respectively), 5) *Odontophrynus maisuma*, 6) *Dendropsophus sanborni*. 7 and 8) *Hypsiboas pulchellus* (green and brown individuals respectively), 9) *Pseudis minutus*, 10) *Scinax berthae*, 11) *Scinax granulatus*, 12) *Scinax squalirostris*. All photos by the authors, except for 10), by Daniel Loebman.

species are *A. siemersi* (CR), *C. ornata* (CR), *M. montevidensis* (EN) and *P. bibroni* (VU) (Canavero et al. 2010). *Odontophrynus maisuma* has not been assessed yet; the rest of the species from the list does not present conservation threats at a national level, so they figure as “Least Concern” (LC) (Table 2). Species considered

as priority for conservation with confirmed presence in Cerro Verde are *L. latrans*, *M. montevidensis*, *P. bibroni* and *O. maisuma*. As they were not found during this study in the area, the species *A. siemersi* and *C. ornata* were considered as potential priorities for conservation.

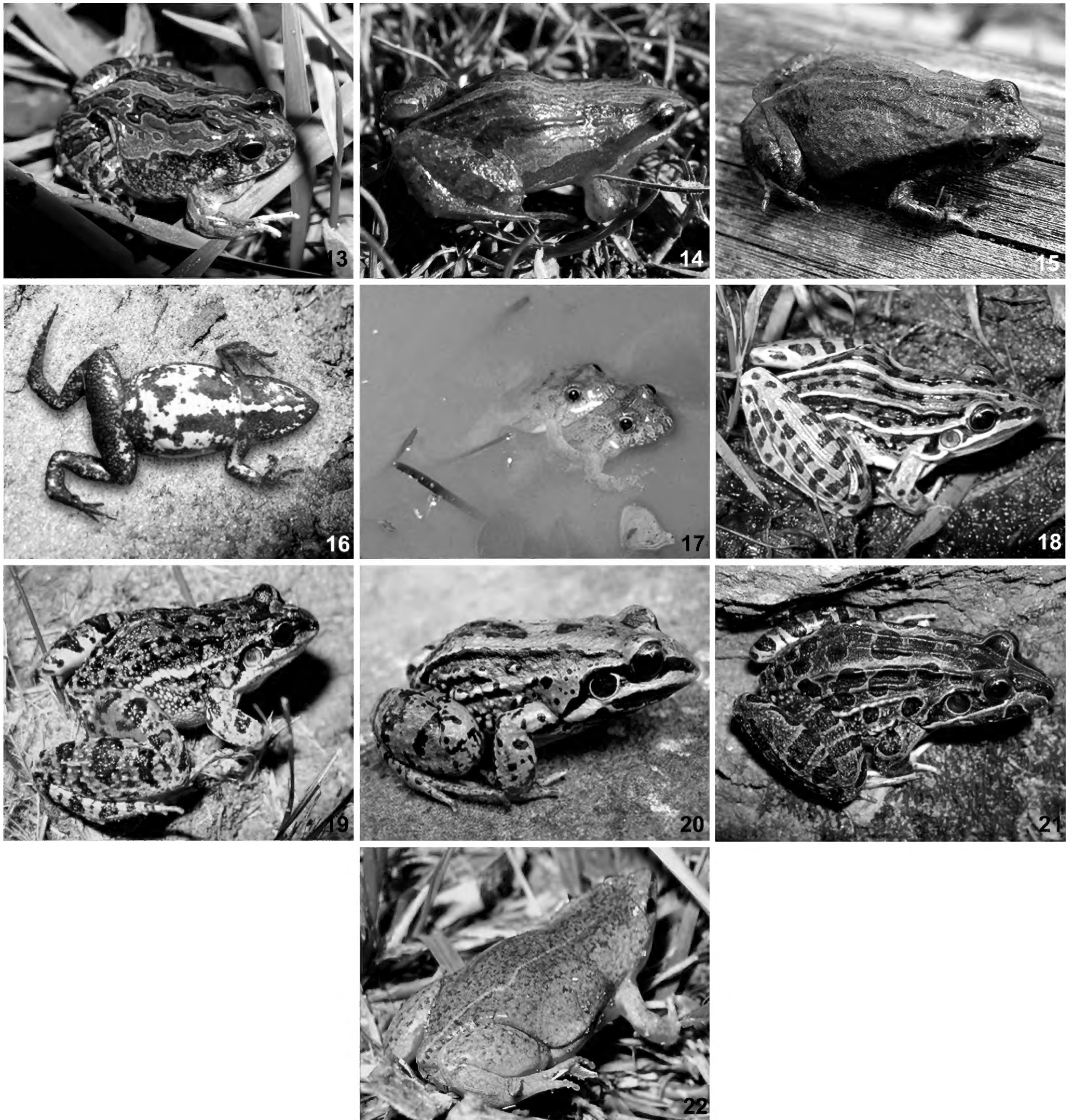


Figure 2. Continued. **13)** *Physalaemus biligonigerus*, **14)** *Physalaemus henselii*, **15)** and **16)** *Physalaemus riograndensis* (dorsal and ventral view respectively), **17)** *Pseudopaludicola falcipes*, **18)** *Leptodactylus gracilis*, **19)** *Leptodactylus latinasus*, **20)** *Leptodactylus mystacinus*, **21)** *Leptodactylus latrans*, **22)** *Elachistocleis bicolor*. All photos by the authors.

Table 2. Total list of species found at Cerro Verde. NS: species found during nocturnal surveys and voucher number (when collected), HR: historic records and voucher number. The categories used for the national conservation status are those stated by Canavero et al. (2010) based on the criteria established for the IUCN Red List (IUCN 2003). CP: conservation priority (*sensu* Soutullo et al. 2013), CPSNAP: conservation priorities for SNAP (*sensu* Soutullo et al. 2013), CPCV: conservation priorities for Cerro Verde considered by this study. Asterisks indicate potential priority species for conservation in Cerro Verde because of their absence during nocturnal surveys.

Family/Species	Source	National conservation status and conservation priorities
Family Bufonidae		
<i>Rhinella arenarum</i> (Hensel, 1867)	NS (ZVCB 13921), HR (ZVCB 2217)	LC
<i>Rhinella dorbignyi</i>	NS (ZVCB 19572), HR (ZVCB 11784)	LC
<i>Melanophryniscus montevidensis</i> (Philippi, 1902)	NS (ZVCB 19584), HR (ZVCB 1432)	EN; CP, CPSNAP, CPCV
Family Ceratophryidae		
<i>Ceratophrys ornata</i> (Bell, 1843)	Núñez et al., 2004 (MNHN 2400)	CR; CP, CPSNAP, CPCV*
Family Odontophrynidae		
<i>Odontophrynus americanus</i> (Duméril & Bibron, 1841)	HR (ZVCB 1709)	LC
<i>Odontophrynus maisuma</i> Rosset, 2008	NS (ZVCB 17164), HR (ZVCB 15076)	NE; CP, CP SNAP, CPCV
Family Hylidae		
<i>Argenteohyla siemersi</i> (Mertens, 1937)	Núñez et al., 2004 (MNHN 866)	CR; CP, CPSNAP, CPCV*
<i>Dendropsophus sanborni</i> (Schmidt, 1944)	NS (ZVCB 18475), HR (ZVCB 11057)	LC
<i>Hypsiboas pulchellus</i> (Duméril & Bibron, 1841)	NS (ZVCB 19543), HR (ZVCB 11210)	LC
<i>Pseudis minutus</i> Günther, 1858	NS (ZVCB 19774), HR (ZVCB 11221)	LC
<i>Scinax berthae</i> (Barrio, 1962)	NS, HR (ZVCB 14559)	LC
<i>Scinax granulatus</i> (Peters, 1871)	NS, HR (ZVCB 11215)	LC
<i>Scinax squalirostris</i> (Lutz, 1925)	NS, HR (ZVCB 11253)	LC
Family Leptodactylidae		
<i>Leptodactylus gracilis</i> (Duméril & Bibron, 1841)	NS, HR (ZVCB 11219)	LC
<i>Leptodactylus latinasus</i> Jiménez de la Espada, 1875	NS (ZVCB 19922), HR (ZVCB 11218)	LC
<i>Leptodactylus latrans</i> (Linnaeus, 1758)	NS (ZVCB 19923), HR (ZVCB 11209)	LC; CP, CPCV
<i>Leptodactylus mystacinus</i> (Burmeister, 1861)	NS, HR (ZVCB 11220)	LC
<i>Physalaemus biligonigerus</i> (Cope, 1861)	NS (ZVCB 17166), HR (ZVCB 15084)	LC
<i>Physalaemus henselii</i> (Peters, 1872)	NS (ZVCB 18148)	LC
<i>Physalaemus riograndensis</i> Milstead, 1960	NS, HR (ZVCB 11277)	LC
<i>Pleurodema bibroni</i> Tschudi, 1838	NS (ZVCB 19776), Kolenc et al. 2009 (MNHN 7352)	VU; CP, CPSNAP, CPCV
<i>Pseudopaludicola falcipes</i> (Hensel, 1867)	NS (ZVCB 18472), HR (ZVCB 11244)	LC
Family Microhylidae		
<i>Elachistocleis bicolor</i> (Guérin Méneville, 1838)	NS, HR (ZVCB 11250)	LC

DISCUSSION

The high diversity of amphibians found during this study was within the expected range because of the geographical location of the study area (Maneyro et al. 1995; Núñez et al. 2004; Maneyro and Carreira 2006). Though, it exceeded the species richness found at Cabo Polonio (11 species) (López 2006), the nearest protected area, and it also exceeded the richness found at Estação Ecológica do Taim, IBAMA (18 species) the nearest protected area on the Brazilian side (Pires et al. 1988).

However, our list from Cerro Verde includes historical records, which implies that some of the species represented there could not occur at the area today. In fact, the inventory built from field surveys was completed at the sixth month of survey, but four species formerly present in the area were not observed during this study: *Argenteohyla siemersi*, *Ceratophrys ornata*, *Odontophrynus americanus*, and *Pleurodema bibroni*. Several reasons are considered for the absence of these species:

***Argenteohyla siemersi*.** This species was considered a

potential priority for Cerro Verde; it has been categorized in Soutullo et al. (2013) as a species that depends on the creation of protected areas for its conservation following four criteria: restricted distribution (it only occurs in two localities in Uruguay), it is a threatened species at a national and global level, and has not been recorded since 1977 (Langone et al. 2004; Canavero et al. 2010; IUCN 2014; Soutullo et al. 2013). This species could be locally extinct, since the last record from the surrounding area was in 1959 in Bañados de Santa Teresa (the only voucher for the locality: MNHN 866), and this wetland has suffered draining for agricultural purposes in recent years (Langone et al. 2004). However, water bodies and wetlands, similar to those where *A. siemersi* breeds and where it used to occur (marshes with dense vegetation; Langone 1994), are not included in Cerro Verde and were not sampled for this study.

***Ceratophrys ornata*.** This species was considered as a potential priority for the same criteria as *A. siemersi*. Some of the water bodies sampled (3 and 4, Table 1)

were similar to those used by this species to breed: temporal ponds formed after heavy rains on grasslands with *Eryngium* sp. (Langone 1994). The species has disappeared from some localities and has not been recorded since 1982 in Uruguay (Langone et al. 2004). For this reason, it is possible that its absence during nocturnal samplings reflects its absence in Cerro Verde, or its populations are considerably reduced.

***Pleurodema bibroni*.** The species was considered as a priority for the area because of its categorization as a species that depends on the creation of protected areas for its conservation (Soutullo et al. 2013). Although many temporal water bodies were surveyed similar to those used by this species according to Kolenc et al. (2009) (2, 3 and 11, Table 1), it was not found during nocturnal samplings; but it was found in the area in a pond which was not being surveyed by this study. In one of the specimens collected, the infection by the fungus *Batrachochytrium dendrobatidis* (*Bd*) was confirmed (Bardier et al. 2011). The disease could explain its population reduction so that this species could not be detected during surveys, but more studies are needed to confirm this.

***Odontophrynus americanus*.** This species was also not found during this study. Its presence could be masked by the similarity of its vocalizations to those produced by *O. maisuma*. Collection records of *O. americanus* from ZVCB (1709 and 1710) are inconclusive, being possible the erroneous determination of this species in previous works (Maneyro et al. 1995; Núñez et al. 2004). So, it is possible that only the recently described species *O. maisuma* is present in Cerro Verde (Rosset 2008), though we cannot discard the presence of *O. americanus* in the area.

Other species considered as priority for Cerro Verde, and found at the site during this study, are *M. montevidensis*, *O. maisuma* and *L. latrans*.

***Melanophryniscus montevidensis*.** This is a very charismatic species which was found during nocturnal surveys. It was considered as a priority for the same reasons of *A. siemersi*, *C. ornata* and *P. bibroni*. This species was found associated to very ephemeral ponds placed in dunes (1, 2 and 3, Table 1). Those environments should be specially considered in the zonation proposed in the management plan of the area because habitat loss has been postulated as one of the main causes for its population reduction (Canavero et al. 2010).

***Odontophrynus maisuma*.** The conservation status of this species has not been formally assessed yet at a national or global level. However, this species has a continental distribution smaller than 200.000 km², justifying its inclusion in the list of conservation priorities of Uruguay

(Soutullo et al. 2013). It was described as a species restricted to coastal regions, associated to the same kind of ponds as *M. montevidensis*, and few populations were identified (Rosset 2008). On the other hand, this species could be threatened because of the presence of *Bd*, which has already been detected in larvae of this species in some localities of the country (Borteiro et al. 2009).

***Leptodactylus latrans*.** This species was also recorded in the area. It is not a threatened species but it is considered as a priority because of its commercial interest, however it does not depend on the creation of protected areas for its conservation (Soutullo et al. 2013).

Finally, Cerro Verde was defined as a Protected Area in August 2011 and its management plan is currently under construction. Whenever the information of species list and distribution within the area, such as the present study, is made available, it would be important to propose a zonation design that includes the distribution of the priority species within the nucleus zone, in order to protect the biodiversity of the area. We also recommend the control for the entrance and dispersion of the *Bd* or another diseases such as dermocystids (Borteiro et al. 2014) in the future management plan of the area.

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